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Timber fire doors

A well-designed door will fulfil its normal functions of isolation, insulation and security without causing too much hindrance to the movement of people and goods. Delaying the spread of fire and smoke is one important aspect of security.

The precise role to be played by doors in various locations in buildings, the methods of assessing performance and the criteria to be applied are topics under active discussion in this country and abroad. This digest gives the current situation and will be revised when these activities have resulted in changes in specifications and requirements.

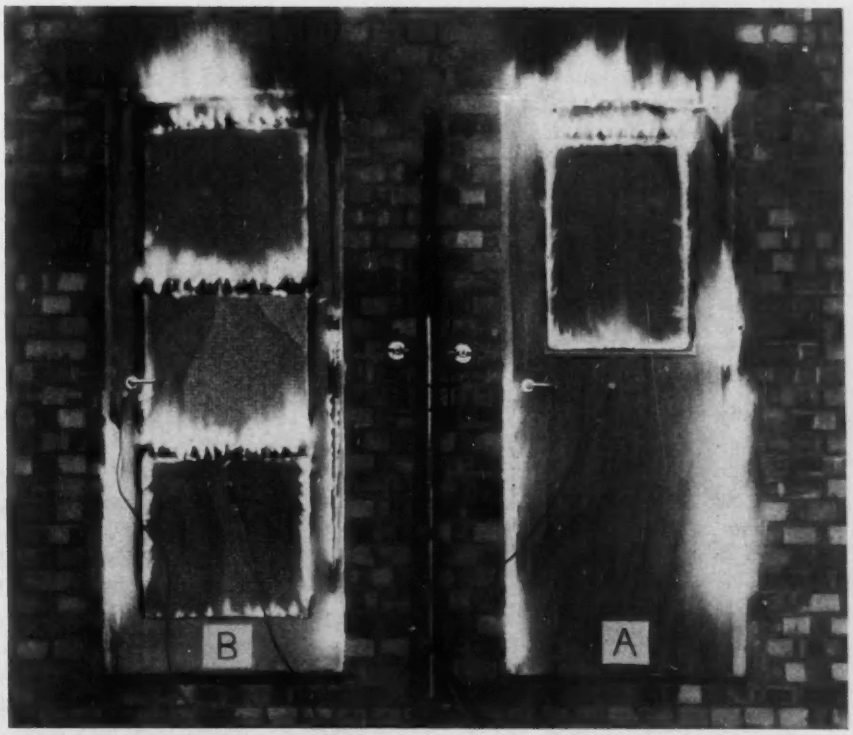

Fig 1 Ignition of glazing beads and door edges

Different parts of a building may be separated from each other into compartments by a fire-resisting construction; any openings leading to and from them will be closed by doors which will have a precise function to fulfil in case of a fire. First, the door should maintain the effectiveness as a fire barrier of the wall in which it is located; secondly, it should prevent excessive transmission of products of combustion which can interfere with the safe use of escape routes. Every fire door is therefore required to act as a barrier to the passage of smoke and fire to varying degrees dependent upon its location in a building and the fire hazard associated with the building.

Functions

The majority of fires start from a small source and develop quantities of smoke in the early stages. The rise in temperature is accompanied by an increase in pressure which tends to force the smoke and hot gases to other areas through any available openings and gaps in the fire compartment. A door in the enclosing walls will be subjected to these pressures and smoke will be forced through any gaps and orifices. As the fire progresses both the gas temperature and the pressure will increase; there may also be some damage to the door which may become deformed and consequently allow greater quantities

of smoke to pass through. The collapse of windows will result in some relief of the pressure but the resulting increase in ventilation can lead to more rapid combustion of the contents. The door is then required to withstand exposure to the high temperature conditions without losing its integrity (See Table 1).

The functions of fire doors may therefore be summarised as:

1 To provide adequate resistance to the passage of smoke and other combustion products during the early stages of a fire.

2 To provide a barrier to a well-developed fire without permitting excessive quantities of smoke to pass.

Some doors may be required to fulfil only the first function as they may not be subjected to the full severity of a fire because of their location; others may have the main aim of resisting fire penetration as indicated by the second function. Some may have to meet both requirements. At present, fire doors are specified as smoke-stop doors when required to fulfil the first function and fire-check and fire-resisting doors to fulfil the second.

Assessment of performance

The performance of timber doors is judged by subjecting them to the standard test procedure specified in BS 476:Part 8. This Standard has recently replaced the specification given in BS 476: Part 1 which was the basis of extensive work on timber doors. As the revised Standard makes a few fundamental changes in the procedure for testing doors reference will be made to both procedures.

Tests are made on complete door assemblies, ie the door and frame with the necessary hardware, mounted in a wall representing its use in practice. By testing a door in one type of frame and using it in another, no guarantee can be given of its behaviour under fire conditions. The test procedure is fully described in the Standard and consists of exposing one face to the standard heating condition whilst observing the door for the maintenance of stability and integrity. The revised Standard requires the tests to be carried out with the upper part of the door under a small positive pressure, to simulate the conditions likely to occur in a fire. It also provides a more objective method of establishing the loss of integrity of a door by the use of a combustible fibrous pad; this was previously established by visual observation. The earlier Standard did not require any measurements to be made of the insulation provided by a door against the transfer of heat but the revised version does so.

Fig 2 Deformation of door

A door should be tested from each side to establish its performance with either face exposed to fire conditions; this requires two specimens but if it can be established that in practice fire is likely to attack only from a specified direction, only that face needs to be exposed in the test.

Fire behaviour

On exposure to high temperatures, charring of the exposed face occurs leading to surface ignition. Burning of the timber from the exposed face and the consequent movement of moisture inside the section causes deformation of the door panel with a tendency to form a concave shape towards the heat source (Fig 2). Timber doors are usually provided with two or three hinges along one vertical edge and a latch at about mid-height along the other. The triangular section at the top and the bottom of the door are free to deform and the maximum movement is likely to occur at the two corners on the closing edge. If the closing face of the door is exposed to the fire conditions, the stops on the frame will restrain this movement but this will stress the hinges and latch. When the opening face is exposed there is no restraint at the corners which are then free to deform. The gaps between the door edges and the frame provide an area which the flames can exploit and the extent of charring is greater than through the solid section. The amount of damage is significantly influenced by the initial size of the gaps, by any increase in gap that may occur by shrinkage and warping of the door and by the flow of hot gases through the gaps.

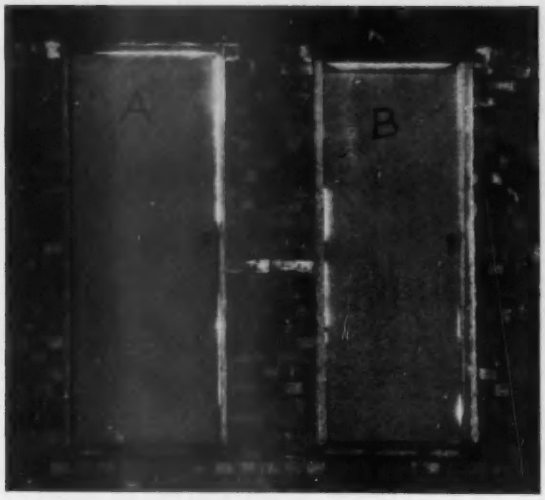

Fig 3 Fire penetration along edges

Gradual deterioration of the door assembly along the edges between the door and frame leads to the transmission of hot gases, widening of gaps, appearance of glowing on the unexposed face (Fig 3) and finally flaming. Initial failure is frequently in the upper half of the door, either along the top edge or the vertical sides close to the hinges. Failure in these areas usually occurs before penetration of fire through the door.

Over the last few years a technique has been developed for minimising the susceptibility of door edges to early penetration by fire. It consists of applying special materials having intumescing characteristics along the edges so that a rise in temperature will cause the material to swell and close the gaps. Intumescent paints have been used but the most successful and reliable technique is to insert an intumescent strip, about 3 mm thick by 10 mm wide, into a groove cut in the door or the frame edge. As soon as the temperature in the vicinity of the strips exceeds 200° C, usually about 10–15 minutes after the start of a fire, the strip swells and seals the gaps (Fig 4). The intumesced material is soft and cellular in structure and will not prevent deformation of the door. For the increased protection needed with one-hour doors, a number of these strips, both in the door and the frame edge, may be necessary. The protection must be continuous and not interrupted at hinges and latch plates.

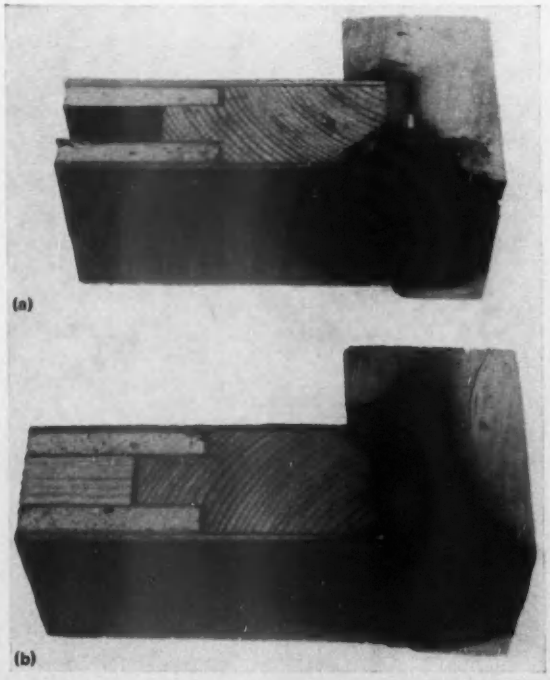

Fig 4 Exposure to fire on door (a) with intumescent strip and (b) without

Specifications

The data in this section are based on the actual performances of a large number of timber doors and frames and are intended to highlight the important features and measures that are necessary. The performance of a given type can be established categorically only by test but an assessment is possible by a close study of the design features.

Smoke-stop doors (Fig 5)

There are no precise definitions available for this type of door and work is in progress nationally and internationally to define criteria and test procedures which may be used for classification. Single-swing doors must be close fitting in a rebated frame with 25 mm deep stops so that despite a pressure difference across the two sides only small quantities of smoke will pass. Additional seals must be provided around the edges if stops are smaller. Normal draught excluders can be satisfactory for a time but only a few types, employing metallic strips, can be relied on to remain effective. The non-metallic types will also become less effective as the temperature rises. Doors to corridors and lobbies which swing in both

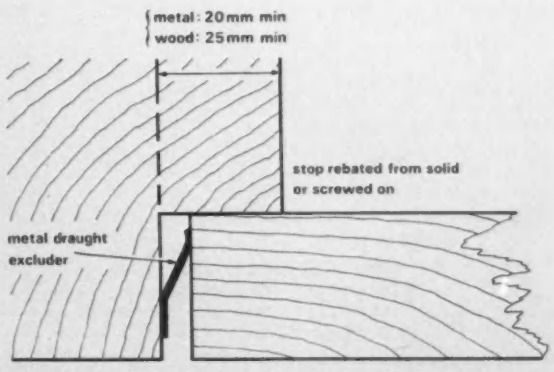

Fig 5 Smoke-stop door

directions and therefore cannot be rebated, are likely to offer less resistance to the passage of smoke. Smoke-resistance can be improved by fitting smoke seals such as the felt brush or flexible polyurethane foam type; intumescent strips will not become effective until the later stages of a fire.

The thickness of smoke doors is not necessarily critical, nor is the size of glazing.

Fire-check and fire-resisting doors (Fig 6)

The distinction between these two types of fire-door is not often fully appreciated. Fire-check doors are those which either comply with the construction specification given in BS 459: Part 3 or have given an equivalent performance in fire tests; fire-resisting doors have a higher standard of integrity. Table 1 illustrates the difference between the two types of door and Table 2 summarises some of the design differences.

A fire-check door has lower integrity than the corresponding fire-resisting door; its use in place of a fire-resisting door will not provide equivalent protection particularly against the passage of smoke during the later stages of a fire.

Half-hour fire-check door The specification given in BS 459: Part 3 is widely used and even with doors of a different design it is customary to use the frame specified in the Standard. The doors are 45 mm thick but some 40 mm doors have been found successful by test: in all cases the frame has 25 mm deep stops which may be glued and pinned or screwed to the frame. The gap between the door edge and the frame should not exceed 3 mm; two or three hinges and a latch are required to hold the door in the closed position (Fig 7). Alternative door constructions which have been shown to be successful are solid timber, compressed straw, extruded chipboard, cork, flaxboard and compressed fibre-board strips. Glazed panels, if any, should consist of wired glass not less

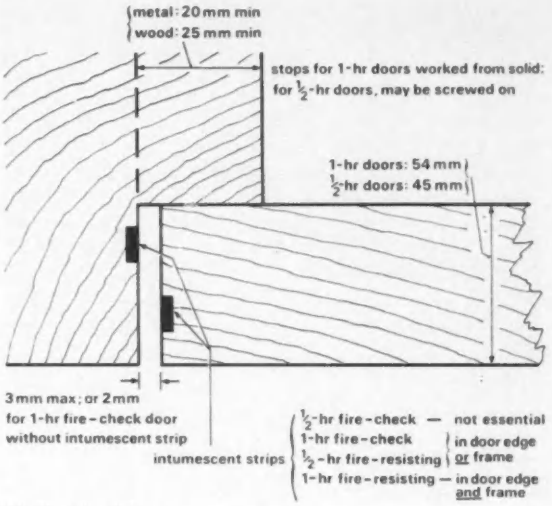
metal: 20 mm min
wood: 25 mm min
stops for 1-hr doors worked from solid:
for ½-hr doors, may be screwed on
1-hr doors: 54 mm
½-hr doors: 45 mm
3 mm max; or 2 mm
for 1-hr fire-check door
without intumescent strip
intumescent strips
½-hr fire-check — not essential
1-hr fire-check — in door edge or frame
½-hr fire-resisting — in door edge or frame
1-hr fire-resisting — in door edge and frame

Fig 6 Fire doors

than 6 mm thick and no more than 1·2 m² in area; the glass should be held in position by timber beading not less than 13 mm square in cross-section, securely pinned or screwed.

Half-hour fire-resisting door As half-hour fire-check door, 45 mm thick, but with three hinges and an intumescent strip in the door or the frame edge. Glazing beads should be protected against ignition preferably by encasement with metal cover strips.

One-hour fire-check doors A specification is given in BS 459: Part 3 for 54 mm thick doors of composite construction with asbestos board mounted in an impregnated timber frame with 25 mm stops cut from the solid or in a steel frame with 20 mm

Table 1 Fire-check and fire-resisting doors

Door type	Integrity(1) *Minutes*	Stability(2) *Minutes*
Half-hour fire-check	20	30
Half-hour fire-resisting	30	30
One-hour fire-check	45	60
One-hour fire-resisting	60	60

(1) Integrity — Failure is deemed to occur when cracks or other openings exist through which flames or hot gases can pass or when flaming occurs on the unexposed face.

(2) Stability — Failure is deemed to occur when collapse of the specimen takes place

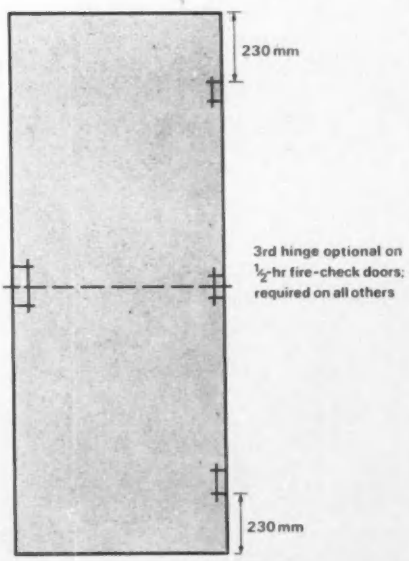

Fig 7 Recommended hinge and latch positions

Table 2 Fire doors: design features (see text for more detail)

Door type	Door thickness	Stops[1]	Glazed panels: max. size	glass	beads	Hinges[2]	Door/frame max. gap	seals
Smoke-stop	Not critical	Solid rebated or screwed on	Not critical	6 mm wired		2	Not more than 6 mm	Draught excluder
½-hour doors: fire-check	45 mm to BS 459 Pt 3 (but see text)	solid rebated or screwed on	1·2 m²	6 mm wired	not less than 13 mm × 13 mm wood	2 or 3	3 mm	—
fire-resisting					Ditto but encased in non-combustible cover strip	3	3 mm	Intumescent strip in door edge *or* frame
1-hour doors: fire-check	54 mm to BS 459 Pt 3.	solid rebated	0·5 m²	6 mm wired	Non-combustible sub-frame	3	2 mm if no seal 3 mm with intumescent strip	
fire-resisting						3 broad flap	3 mm	Intumescent strips in door edge *and* frame

(1) Stops to be at least 25 mm deep in wood frames, or 20 mm deep in metal frames

(2) All doors require, in addition, a substantial latch and latch plate

stops. The gaps between the door edge and the frame should not be more than 2 mm unless intumescent strips are used; the use of intumescent strips is desirable in 1-hour doors. At least three hinges and a substantial latch and latch plate are needed. The door constructions which have been shown to be successful include blockboard, compressed straw and cork cores with asbestos facings and veneer. Glazing of 6 mm wired glass in pane sizes not exceeding 0·5 m² should be mounted in a non-combustible sub-frame. The most successful method is to use profiled asbestos or glass-fibre reinforced cement framing members. Steel beading may be successful provided it is so fixed that it does not distort on expansion. The beading or framing to the door must not provide a point of weakness; the use of intumescent paints, cover strips or recessed joints will be necessary. The glazing frame should be fixed with long screws or nails from each side to ensure its retention after nearly 35 mm of timber has been charred from either side.

One-hour fire-resisting doors As for one-hour fire-check doors but with special design to prevent fire penetration at the edges. Double sealing with intumescent strips is essential as well as the use of extended flap hinges and latch plates. The frame should preferably incorporate a non-combustible membrane which may be faced with timber veneer. Very few one-hour fire-resisting doors are commercially available and there is scope for development by the use of intumescent sheet material embedded below the decorative facing of the door and the frame.

Existing doors Occasionally it is necessary to improve the performance of an existing door to a half-hour fire-check or fire-resistance standard, although in practice it may be more economic to replace the door with a fire-check or fire-resisting door rather than alter it. The doors are usually either panel type or a light core flush type about 35 mm thick: they require a facing on each side of quarter-

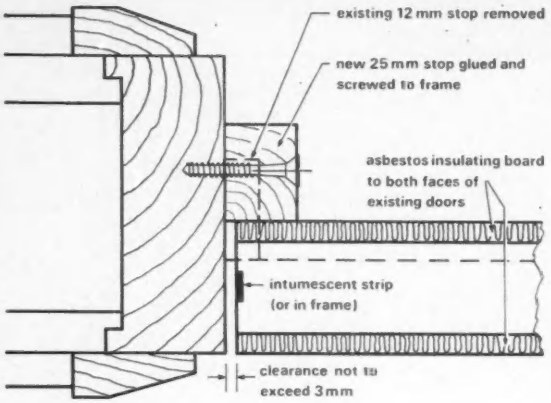
existing 12 mm stop removed
new 25 mm stop glued and screwed to frame
asbestos insulating board to both faces of existing doors
intumescent strip (or in frame)
clearance not to exceed 3 mm

Fig 8 Conversion of an existing door

inch (6·4 mm) asbestos insulation board. The stops on the frame are likely to be 12 mm or less; these have to be removed and replaced by 25 mm stops, glued and screwed in situ. It is important that the finished door should not be deformed and that clearances do not exceed 3 mm. To meet the fire-resistance standard, it will be necessary to provide an intumescent strip in the door or the frame edge (Fig 8).

No advice is possible for improving the performance of existing doors to a one-hour standard but more elaborate protection will obviously be necessary and the biggest problem is likely to be the improvement necessary along the door and frame edges.

Glazing

Glazing may range from a small vision panel in a door to a glazed screen with hinges for maximum light transmission. Ordinary glass cracks when exposed to heat and is liable to fall out fairly early in a fire. Wired glass 6 mm thick can withstand exposure to the heating condition in a fire test for at least 60 minutes before it reaches a temperature high enough to soften it. The main reason for this is that nearly 50 per cent of the incident heat is transmitted through the glass by radiation.

The size of the glass and the method of its retention are important factors which influence its integrity. As the temperature approaches the softening point a large sheet will tend to collapse earlier than a smaller one. On the unexposed face, beading retaining the glass is subjected to radiant and conducted heat through the glass and to convection currents at the top of the pane. This can raise the temperature sufficiently to ignite timber beading after about 20 minutes (Fig 1). To delay the ignition of beading to 30 minutes it is necessary to provide protection by impregnation, surface coating or a surface covering of non-combustible material. For longer periods of fire protection, an improved retention system for the glazing is needed; so far only non-combustible glazing sub-frames have been shown to be satisfactory. The glass panel should be small and the method of fixing it should ensure that no direct path can be created for the transference of hot gases.

Fittings and furniture

Hinges and latches have an important role in ensuring the integrity of the door. The hinges must remain adequately screwed, in spite of the charring of wood in the vicinity, to provide the necessary fixing to the edge of the door. It is common to use three hinges although tests have shown that with some doors two hinges may be adequate for the half-hour period. Steel and brass hinges are effective for a half-hour door, but only steel hinges will be satisfactory for a one-hour door. For the latter, it may be necessary to use hinges with extended flaps (broad butts) so that fixing is maintained even when severe charring has taken place.

The latch is the only holding device on the closing edge, hence it is important that it should be strong and that the nib of the latch should engage into the latch plate at least 12 mm to ensure that the closing edge will not spring open when the door deforms. Extended-flap latch plates are advisable for one-hour doors. Where mortice locks are provided, the cut-out in the door should be the minimum necessary to prevent any voids which fire can penetrate. After the edges, the mortice lock and latch areas represent the next zone of weakness. Filling the voids in the cut-out with intumescent paste will markedly lessen the weakness in this area.

Plastics and aluminium handles and knobs will be destroyed on the fire side but this may not have a serious effect on the integrity of the door if steel spindles are provided. Letter plates introduce a weakness in a door. No investigation has been carried out to establish a design for satisfactory performance, but those made of aluminium are likely to melt and even with steel flaps deformation can lead to integrity failure. A double flap of steel, one on each side of the door, is likely to be necessary to maintain integrity. Letter plates should ideally be positioned in the lower part of the door.

Self-closing devices can suffer damage and consequently become inoperative if they are surface mounted on the exposed face. If their sole function is to close the door with a latch, when they have done so any damage suffered need not be critical for the integrity of the door. Recessed self-closing devices will suffer less damage, but in the top of the door panel can produce a local weakness. The ideal place is within the sill where it will cause the least interference with the performance of the door. The Building Regulations set out the circumstances in which rising butts may be used: where they are fitted, compensation must be provided for the cut-out from the top edge of the door by increasing the depth of the stop (Fig 9).

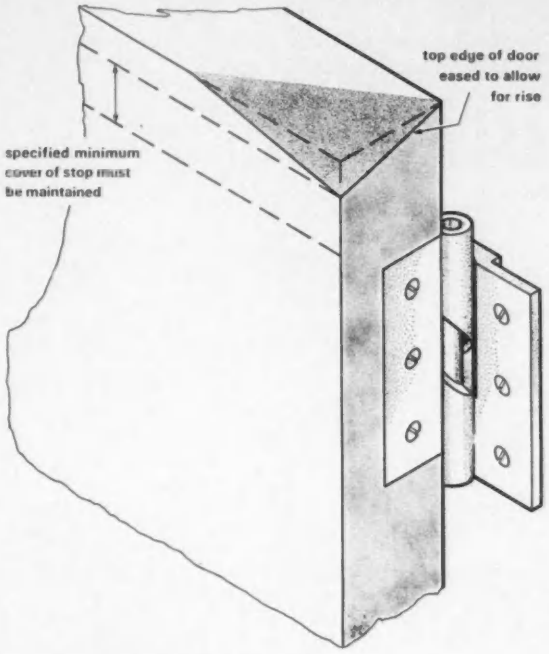

Fig 9 Rising butts need a deeper stop

A self-closing device used with double swing doors should not only close the door but also hold it firmly in the closed position. It needs to be strong enough to keep the door closed against any pressure to which the door leaf may be subjected in a fire. The only type of device which has been shown to be successful is a spring type mounted in the sill.

British Standards

BS 459 Part 3:1951 Fire-check flush doors and wood and metal frames (half-hour and one-hour types).

BS 476 Part 1: 1953 Fire tests on building materials and structures.

BS 476 Part 8: 1972 Test methods and criteria for the fire resistance of elements of building construction

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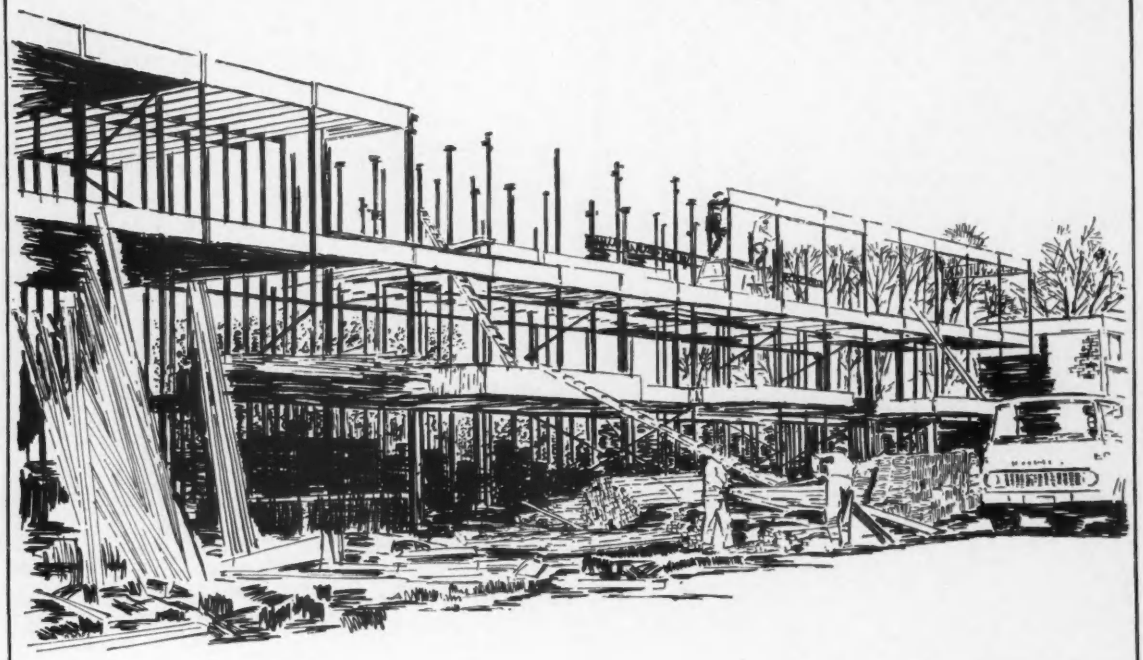

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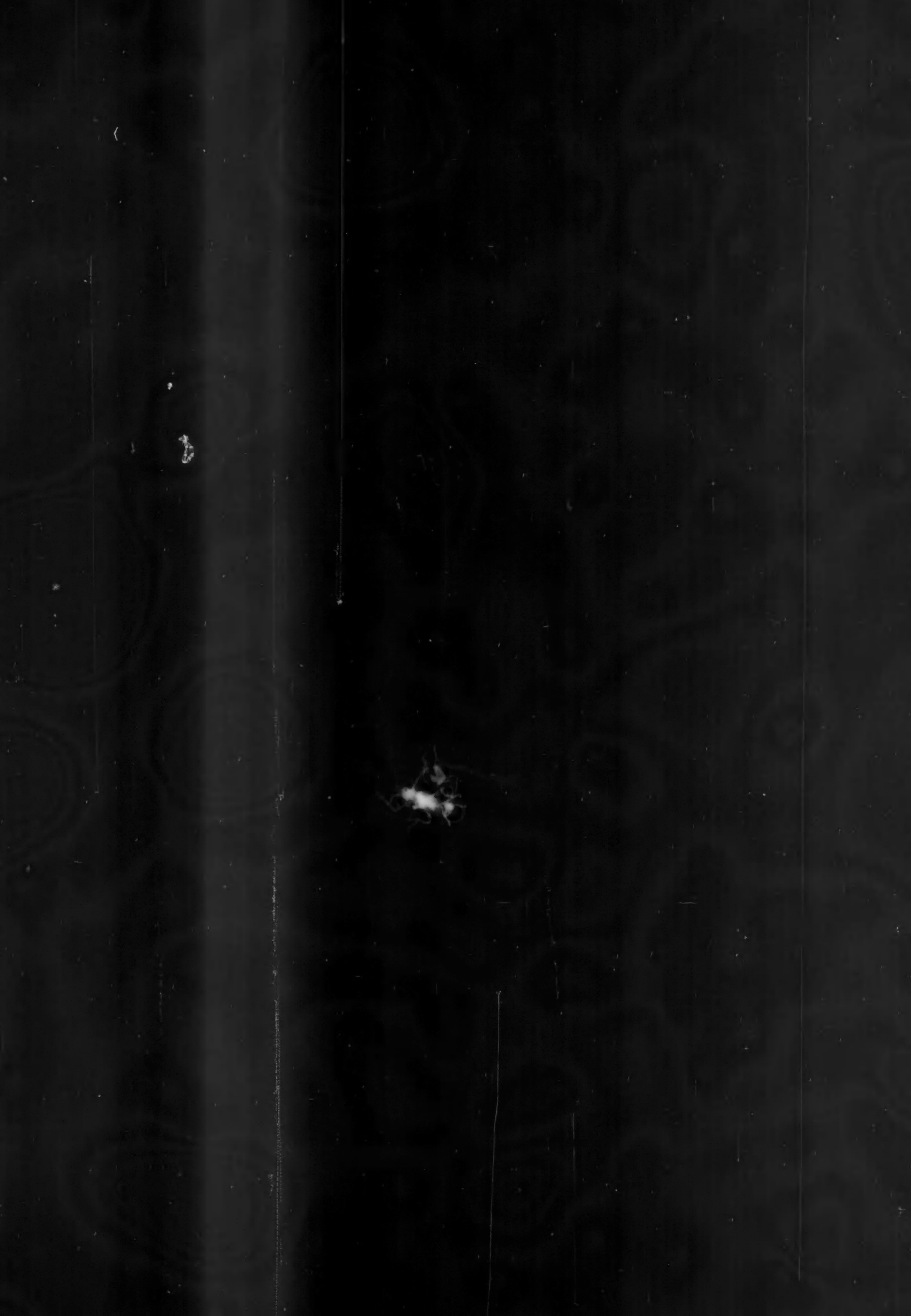
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